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Transaction Network, Telephones, and Terminals:

Maintenance and Administration

by L. R. BEAUMONT and K. W. SUSSMAN

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This paper describes the maintenance and administration plans which have been developed for the Transaction Network to provide a reliable and maintainable new service while fitting into the existing operating telephone company environment. The polled access network is used as an example to show how high reliability is obtained and how the procedures developed to manage the daily activities are used.

I. INTRODUCTION

Transaction Network Service and the equipment and operational programs developed to implement the message switch communications system which provides the service are described in Refs. 1 to 4. The service has been designed to operate in the existing operating telephone company environment, using existing facilities, craft forces, and administrative and maintenance organizations. To meet the objectives of a highly reliable, available, and maintainable total service, procedures have been developed which fit the service to its operating environment.

This paper describes those maintenance and administrative capabilities and procedures.

II. TRANSACTION NETWORK CUSTOMER SERVICE BUREAU

A single organization, the Transaction Network Customer Service Bureau (TNCSB), has responsibility for the overall end-to-end control and quality of customer service. The TNCSB is located in an existing special service organization serving the area in which Transaction Network (TN) operates and has the following responsibilities:

(*i*) Remain staffed 24 hours a day, seven days a week.

(*ii*) Input all service order information (called "recent change" messages) into the message switch.

(*iii*) Receive any messages automatically sent to it by the TN.

(*iv*) Receive and analyze all customer trouble reports.

(*v*) Perform remote testing in association with message switch or Switching Control Center personnel to sectionalize troubles based on customer trouble reports or automatically generated trouble reports.

(*vi*) Maintain office records on the TN.

(*vii*) Serve as an interface between TN customers and other Bell System offices to resolve problems.

(*viii*) Monitor and coordinate all order and maintenance activity.

The next section of this paper describes the facilities provided by TN to allow the TNCSB to perform these functions.

III. MAINTENANCE FEATURES OF THE TRANSACTION NETWORK SYSTEM

3.1 Introduction

The preceding section discussed the responsibilities of the TNCSB in coordinating the maintenance activities needed to insure that TN provides reliable service. In this section, the hardware and software features available within TN to provide for this maintenance are described in general, and the maintenance features of the polled access circuits (PAC) are described in detail.

3.2 Available maintenance features

3.2.1 Processor maintenance

Since all features, including maintenance, of TN are provided via control of the central processor, it is essential that the processor itself be reliable and maintainable. In TN this is accomplished by using a duplicated Auxiliary 3A Processor (Ref. 5). One processor operates on-line, and the other is normally in a standby mode, ready to become the active processor within milliseconds. Each processor includes its own central control, associated memory, and input/output (I/O) channels. During normal operation, the memories of both the on-line processor and the off-line processor are written into simultaneously from the working on-line unit. The 3A Processor maintains parity over every word in its main store, and over every general and special register, including those used to access the I/O channels. During the execution of every instruction, after the datum is gated to the data bus internal to the processor, its parity is checked. If this parity is incorrect, an error interrupt is generated. This interrupt results in a switch to the standby processor.

In addition to parity checks on every datum gated onto the data bus, the 3A Processor has two other major hardware features designed to

increase its reliability. The first is a duplicated data manipulation logic (DML) unit, and the second is the program timer.

Since parity is not preserved over logical and arithmetic functions, parity checking is not suitable to ensure that these functions have been performed correctly. Each 3A Processor contains two data manipulation logic units. To execute any instruction which requires a logical or arithmetic operation, each of the two DML units performs the computation, then their results are compared. Failure of the two DML units to match indicates that one is in error and generates an error interrupt. This interrupt results in a switch to the standby processor.

It is also possible for the 3A Processor to stop executing machine instructions. This could occur if the contents of memory were destroyed, for example, or if an error condition was first encountered while interrupts were blocked. To ensure a minimal service outage in the instance of these faults, a program timer is provided. The programs executing in the processor are responsible for resetting this timer periodically. If it is not reset, it causes a Maintenance Reset Function (MRF) in *both* processors, causing the one without the fault to resume processing.

In addition to these hardware features designed to provide processor reliability, the processor is supplied with software audits also designed to provide increased reliability. A low priority task[4] continually compares the contents of the off-line processor's main store to the contents of the on-line processor's main store. A mismatch is indicative of a memory failure. The mismatch is recorded by a TTY message.

3.2.2 I/O channel maintenance

The reliability gained from the automatic maintenance features of the 3A Processor is considered sufficiently high to allow the processor to control the maintenance of the remainder of the network, without further regard to a processor failure. What has been provided with TN is the ability to rapidly identify equipment containing a hardware fault, and the further ability to chose alternative equipment for providing service to any customer in the event of any independent hardware fault in the network, with the exception of a failure in the access to a single polled terminal. In addition to the ability to identify failed equipment and to reconfigure the network, the capability to diagnose the failed equipment is also provided. This ability allows craft personnel to locate the circuit pack or other circuit element responsible for the equipment failure and to verify that it has been properly repaired.

Figure 1 illustrates how each TN peripheral device is interfaced to the duplex 3A Processor. Each processor is equipped with a single Main-

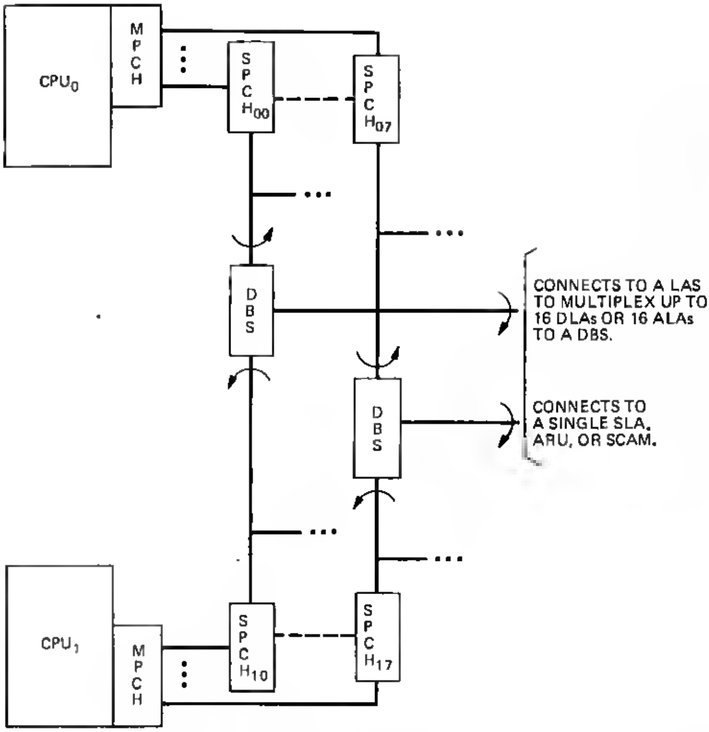

Fig. 1—Switch configuration.

Parallel Channel (MPCH), which is equipped with from two to eight subparallel channels (SPCH). Each subparallel channel serves from 1 to 16 Duplex Bus Selectors (DBS). Each TN peripheral device is connected to a DBS. This I/O channel arrangement allows either processor to connect to each of the peripheral units, allowing continued service in the event of a processor switch.

The DBS has a status register, a bus loopback register, and the ability to respond to commands from the on-line processor. These hardware maintenance facilities are sufficiently complete to allow the software to determine if the on-line processor is able to properly access its DBS port. This constitutes a test of the MPCH and the SPCH as well as the DBS port. Failure of this test is the stimulus used to request a processor switch as part of the network reconfiguration strategy.

A strict protocol involving timing of control signals and parity checking of the data being sent must be observed between the processor and the peripherals on the I/O channel. This serves as a continual check on the operation of the channel. Failure of the protocol initiates recovery programs responsible for maintaining the affected device.

3.2.3 Polled network maintenance

Figure 2 shows the polled network configuration. A polled access circuit is comprised of two polled access lines that serve a collection of terminals connected to a Data Station Selector (DSS), which itself is dualized. Each polled access line consists of a port of the message switch, a line facility, and one-half of the common portion of a DSS. Each polled network port of the message switch consists of a line adapter including an integrated modem (Asynchronous Line Adapter ALA). Sixteen ALAs are multiplexed into a single DBS by one Line Adapter Selector (LAS). Each facility is terminated at both ends by an 829 Data Auxiliary Set, one located at the ALA and the other included in the DSS. The DSS serves a collection of terminals, each connected to it via an unduplicated facility. See Ref. 3 for a complete description of this polled access network equipment.

During normal operation, both access lines in the dualized arrangement are active; polling, receipt of inquiry messages, and delivery of response messages take place on each line independent of the other. When it is necessary to suspend service over one of these paths for

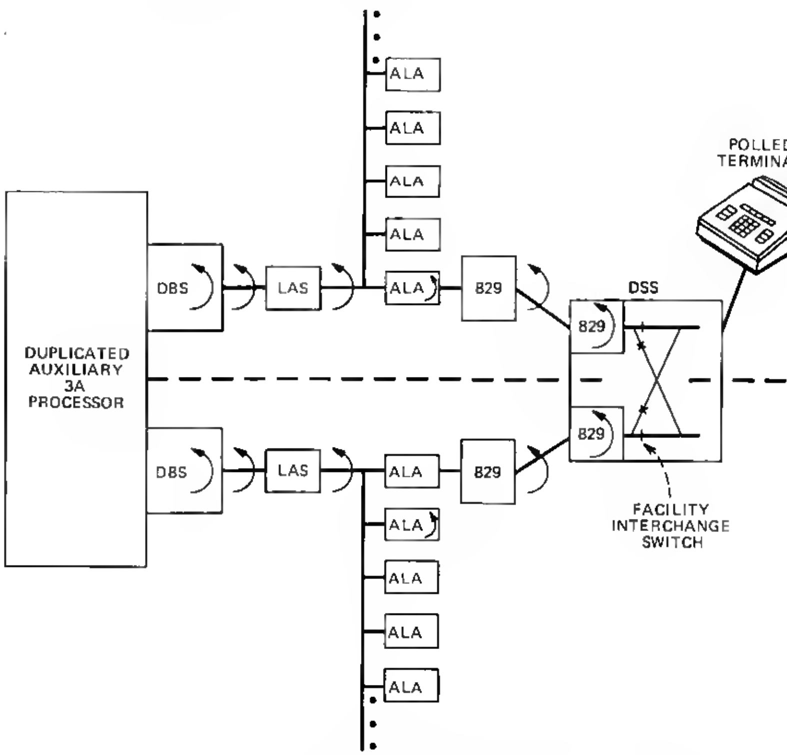

Fig. 2—Asynchronous polled access line configuration.

maintenance purposes, it is possible to carry the combined terminal traffic load over the other (buddy) line. The network can thus be reconfigured to allow maintenance activity (testing, diagnosis, or repair) on any one of a pair of access circuits, while retaining service (at a somewhat reduced level) to all terminals served by the pair.

Polled call processing programs and other software known as polled periodic maintenance provide surveillance over the polled network. Whenever a problem is suspected by either of these programs, another program called the polled recovery task is automatically invoked to investigate and act upon the suspected problem.

Polled call processing provides surveillance of the network by continually checking that each I/O order sent to the periphery obeys the protocol defined for the channel. Failure of an I/O order indicates a fault in the polled network. Polled periodic maintenance provides surveillance by utilizing a transponder located in each half of each DSS. This transponder is called the DSS test message generator. Upon command, the DSS transmits to the message switch a fixed-length message containing maintenance information regarding the DSS and the loops served by it. Failure of periodic maintenance to be able to obtain this message indicates a fault in the polled access circuit.

An error, suspected either by polled call processing detecting a failed I/O instruction or by polled periodic maintenance failing to obtain a valid test message upon command to a DSS, causes the polled recovery task to take action on the indicated polled access circuit. The polled recovery task uses the maintenance features provided by the hardware to resolve the fault to one of the following:

(*i*) A power supply serving the ALA unit.
(*ii*) The DBS serving the ALA unit.
(*iii*) The LAS.
(*iv*) The ALA.
(*v*) A facility to the DSS.
(*vi*) The DSS.
(*vii*) No trouble found.

In cases (*i*) to (*iii*), service is suspended on the lines served by one DBS. This would be a minimum of one line and a maximum of sixteen lines. In cases (*iv*) to (*vi*), service is suspended on only the one line. In case (*vii*), only a counter is incremented. If the count rises above a threshold before being periodically reset, however, the associated line is removed from service. Whenever a line is removed from service, craft personnel are alerted by a TTY output message, a lamp on the processor's System Status Panel, and via an audible alarm. The system is also reconfigured to provide service despite the fault, if such a configuration exists.

After the system has automatically detected, isolated, and announced a hardware fault, craft action is needed to deal with the problem. Since

the network has also been automatically reconfigured to provide service despite the fault, immediate craft action is not vital, but rapid personnel response is desirable to repair the fault promptly.

If a DBS, LAS, ALA, or DSS was reported as faulty, tbe craftsperson can utilize diagnostics provided by the software to further isolate the fault. Under control of a TTY command, the specified device is exercised by the diagnostic in a sequence of tests designed to provide maximum resolution of any fault existing in the device. If one of these tests fails, a trouble number is printed on the TTY. When this number is looked up in the trouble locating manual (TLM), a detailed description is provided of what function of the device the failing test was exercising, how it failed, and what circuit pack of the device is probably at fault. Furthermore, a detailed repair procedure for each device is provided. These tools guide craft in performing the appropriate repair. When the device is successfully repaired, the diagnostic will end with an all-tests passed (ATP) printout whenever it is run. After an ATP printout is obtained on the device which was faulty, the device can be restored to normal service, causing the network to be reconfigured to include the restored device.

If the facility to the DSS is reported as faulty, standard repair procedures may be used because the facility is accessible at either end via the 829 DAS. The DSS diagnostic is used to verify that the repairs were successfully made to the facilities. Once the repairs are successfully completed, the affected line can be restored to service.

The DSS hardware provides surveillance of the loops to individual polled terminals. As part of the test message which can be sent by the DSS to the message switch, a bit for each loop served by the DSS is included. This bit is cleared by the DSS for every loop which is open. Polled periodic maintenance uses this information, along with a mask used as a record of which terminals are installed, to announce that a loop is open.

3.2.4 Dialed network and CSC maintenance

The concepts of fault detection and isolation, network reconfiguration, fault diagnosis and repair, and restoring devices to service, which were explained in detail above for the polled network, apply in principle to both the dial network and the CSC network. These networks are not dualized. The CSC network maintains a spare Synchronous Line Adapter/Data Set combination for each type (speed) of service. This can be switched in for maintenance purposes via a relay controlled by the Switch Control and Monitor (SCAM). The dial network relies upon replication to deal with hardware faults. The SCAM can be used to operate a relay to make any dialed port appear busy to the hunting group. Subsequent calls to the network will not use a busied-out port until it is restored. The SCAM also controls loop-back relays used to test the data sets in each of these networks.

IV. ADMINISTRATION

The preceding sections have defined the maintenance capabilities and procedures that have been developed for the Transaction Network. This section discusses the administrative procedures designed to enable an operating telephone company (OTC) to manage the daily activities necessary to successfully operate the service. These procedures cover the activities required to respond to customer requirements for new and/or additional service, maintain the record systems that define the service provided, and generate administrative reports that aid in managing the service.

The provision of service to a Transaction III terminal on an existing Transaction Network polled access circuit will be used as the vehicle to describe these administrative procedures.

4.1 Service order process

The process by which a request for service is translated into the provision of that service is known as the service order process. The process begins with the customer negotiation phase where the OTC marketing representative works with the customer to define the service required, including the appropriate service options. A document called a service order is generated and is the source document used by all the OTC departments involved. The departments add information to the service order as each phase of activity is concluded until the service has been provided and the service order is filed in an in-service file.

The initial service order generated by the marketing representative is sent to: comptrollers to begin the billing record generation, engineering for circuit layout and engineering if required, network administration for port and number assignment, plant assignment for local cable pair and frame assignment, and the Transaction Network Customer Service Bureau (TNCSB) for coordination of these efforts and review. The results of the above activities lead to a work order which directs the activities of the local Central Office, message switch, Customer Installation and Repair, and Repair Service Bureau craft forces to install and perform the pre-service tests. Upon completion, the billing record, circuit layout, and line records are put in final form and the service order is placed in the in-service file at the TNCSB.

Example: In this example, the customer wants to install a Transaction III terminal and obtain restricted polled access service to a specified set of Customer Service Centers (Restricted Service List 001 on the message switch) which this customer is entitled to use. The Transaction III terminal is optioned for the terminal ID feature and the ALL-DIGITS option is not appropriate in this case. (See Section 4.5 for definitions of these features.) The CSCs have optioned to pay for all messages from and to the restricted polled terminals.

4.2 Network administration

The network administrator is responsible for assembling all recent change data (see Section 4.6). Most recent change data consist of assignments prepared by the network administrator, equipment arrangements prepared by the equipment engineer, general office arrangements prepared by the network design engineer, and customer data collected by the marketing representative. Forms have been developed (see Section 4.5) which, when completed, contain all the information necessary for the preparation of recent change messages which create control blocks in the message switch to define the services installed. These forms are the manual versions of the Office Records System under development for the Transaction Network Service.

4.3 Number plan assignments

The network administrator assigns a unique seven-digit number to each polled terminal, CSC group and line, and dial-in port on the message switch. This number appears on all administrative records and reports, identifies all stations under control of the message switch, and is the basis for call routing in the network. To accommodate the Transaction Network Service multiple exchange billing plan, the network administrator additionally assigns a three-digit Transaction Network Exchange (TNE) code to each station which uniquely defines each exchange in the serving area. The TNE of the calling and called party is included in the billing record written by the message switch but is not used for routing purposes, i.e., for billing, a 10-digit plan is used, but for routing only 7 digits are necessary.

4.3.1 Message switch

Each Transaction Network message switch is assigned a unique three-digit number from the range 300 to 899. This three-digit number is the prefix of the seven-digit number plan, i.e., every station served by message switch 300 has a number of the form

300 XXXX,

where X is any digit from 0 through 9.

4.3.2 CSC assignments XXXX = 0010 → 0998

CSC groups are assigned numbers in ascending order in the range 0010 to 0499. Numbers in the range 0000 to 0009 are reserved for implied and abbreviated addressing. CSC lines are assigned numbers in descending order in the range 0998 to 0500 to identify the individual lines within the group for maintenance and service message purposes.

4.3.3 Service message assignment XXXX = 0999

The number 0999 is reserved for the routing of service messages from polled terminals and CSCs to and from the message switch.

4.3.4 Polled terminal assignment XXXX = 1000 → 7999

Polled terminals are assigned numbers in ascending order in the range 1000 to 7999. The number assigned to a specific terminal remains with that terminal while on the message switch, independent of any physical movement of the terminal or reconfiguration of the serving polled access circuit.

4.3.5 Dial-in port assignments XXXX = 8000 → 8999

Numbers within the range of 8000 to 8999 are uniquely preassigned to dial-in ports based on the hardware used. These ports may be assigned to any telephone number.

4.3.6 Reserved XXXX = 9000 → 9999

Numbers within this range are reserved for future application.

4.3.7 TNE codes

TNE codes are assigned from the range of numbers 200 to 299 on the message switch. The numbers in the range 000 to 199 are reserved for future use.

4.4 Polled access network administration

4.4.1 Assignment

The network administrator assigns each polled terminal to a port on a Data Station Selector (see Refs. 3 and 6) and to a polling list on the polled access circuit. To enhance the availability of service to a multiple terminal/single location customer, the administrator will spread the assignments over different port cards on the DSS and assign the terminals equally to both polling lists for the DSS.

The network administrator using traffic estimates for the polled terminal provided by the marketing representative assigns the terminal to a polling list after determining that the access delay obtained will still meet the 1.25-second objective. An attempt is made to maintain a load balance between the two halves of the polled access circuit. The relationship between traffic and access delay is discussed in Sections 4.4.2 and 4.4.3.

4.4.2 Traffic considerations

The amount of traffic that can be carried on half a polled access circuit is a function of the number of terminals served and the number of messages transmitted by the terminals. To be consistent with existing traffic practices, the traffic is expressed in CCS (hundred call seconds), and the "holding time" for a message is converted from an estimate of the text characters in the message by adding 30 characters for message heading and protocol overhead and multiplying by the character time of 8.33 milliseconds.

The number of CCS of traffic is calculated in the normal fashion using the average busy season (ABS) busy hour transaction rate and the sum of the inquiry and response holding times.

4.4.3 Traffic curves

Figure 3 shows the relationship between total CCS on a polled access circuit half and the number of terminals generating that CCS to yield a constant average access delay of 1.25 seconds. The inquiry plus response holding time of the average message is the parameter of the figure.

Example: In this example, assume that the restricted-access polled terminal is assigned the number 7271003 in TNE 200. The network administrator uses traffic measurements (see Section 4.8) for the polled access circuit which has a primary DSS in the central office that serves the terminal to determine if the terminal can be added to the circuit.

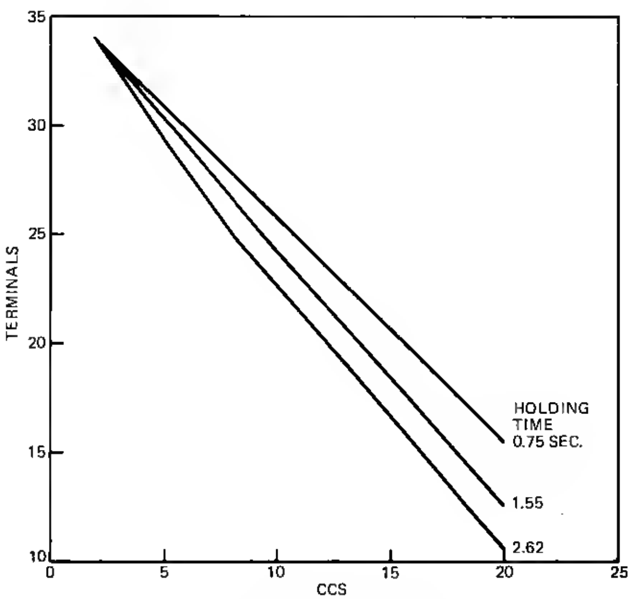

Fig. 3—PAC capacity.

Using the traffic estimate provided by the marketing representative, the administrator checks that the access delay objective is still met with the addition of the terminal and then assigns the terminal to the eleventh DSS port and the polling list corresponding to the odd-numbered line adapter unit. For this example, line adapter units 0 and 1 and circuit number 0 are used. This information will be entered on office records which are discussed in following sections.

4.5 Office records

Forms have been developed which, when completed, contain all the information necessary for the preparation of recent change messages. These forms are in the format of records used in the Office Records System currently under development.

Example—Data Station Selector Record: Figure 4 shows a Data Station Selector Record which contains the information required to prepare recent change messages for the polled terminals served by a specific DSS. An additional form is used to define terminals served by any secondary DSSs connected to the specified primary DSS.

The TNE of the polled access circuit and the prefix of the Message Switch are filled in the heading entry along with the city and state of the Message Switch location. The following paragraphs define the entries on the form.

Item 00–This entry immediately below the heading designates the DSS as a primary or secondary and identifies the even-numbered asynchronous line adapter hardware (ALAH) unit and asynchronous line adapter (ALA) unit number. If the DSS is a secondary, the lowest numbered primary DSS port serving the secondary is also entered.

ALA Unit—The number of the ALA unit which serves the specific terminal on the DSS. Range 00 to 15.

ALA Circuit—The number of the ALA circuits which serve the DSS. Range 00 to 15.

Terminal Port—The primary DSS ports to which terminals are assigned. (Ports 0, 7, 63 are never assigned to terminals, but are included for completeness.) Ports assigned to secondary DSS or reserved for that assignment are not listed in this column.

Secondary Port—On a record for a primary DSS, the port which serves a secondary DSS or is reserved for that use. On a record for a secondary DSS, the primary port which polls the corresponding Secondary Terminal Port.

Secondary Buddy Port—The primary DSS port which serves the secondary DSS in addition to the primary DSS port listed under Secondary Port.

Secondary Terminal Port—The secondary DSS ports to which terminals are assigned. (Ports 0, 7, 63 are never assigned to terminals, but are included for completeness.)

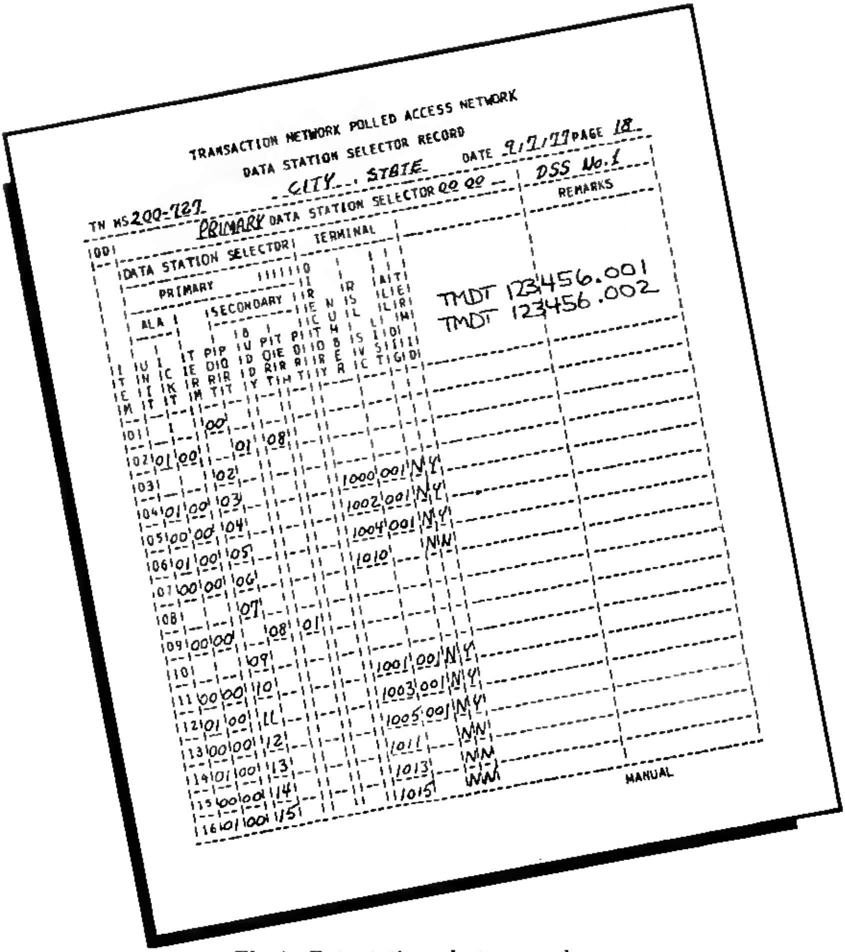

Fig. 4—Data station selector record.

Directory Number—The last four digits of the seven-digit number assigned to the polled terminal (also known as the terminal ID). Range 1000 to 7999.

Restricted Service List—The number of the restricted service list which is assigned to a restricted terminal. Range 001 to 255.

All Digits—Specifies if the full seven-digit number of the CSC must be transmitted to the polled terminal in response messages. Y = Yes, N = No.

Terminal ID—Specifies if the last two digits of the terminal ID are transmitted by the polled terminal in control sequences. Y = Yes, N = No. For Transaction III terminals, always enter Y.

Example: In the example, tbe entries in Item 12 as entered by the network administrator define the assignment parameters for terminal 727 1003.

4.6 Recent changes

Recent change messages entered into the message switch from a teletypewriter are the means by which the memory of the switch is updated to define new services, additions, and/or modifications to existing services on the Transaction Network. The recent change messages are first entered into the on-line memory, while the off-line memory is maintained in its previous state. When the recent change messages have been successfully entered, the off-line memory is updated. The ability to verify recent change messages is provided, and checks are built into the message switch to audit the data entered.

Example: In this example, Item 12 of Fig. 4 defines the data entries for the recent change messages necessary to add terminal 727 1003 into service.

To define the control block for terminal 1003, the following recent change message is entered:

RCP:NEWTERM:DN727, 1003
LINE 1,0
POLL 11!

where RCP signifies a recent change message for a polled terminal, NEWTERM defines an addition, and DN stands for directory number. The entries following LINE are ALAH and ALA numbers on Item 12 and the entry following POLL is the terminal port entry on Item 12. / signifies another line follows and ! ends the message.

To assign the terminal to restricted service list 001, enter:

RCP:TERM (727, 1003), LINE (1, 0), RSL 001!

To define the ALLDIGITS and TERM ID options chosen, enter:

RCP:TERM (727, 1003), LINE (1, 0), ALLDIG, NO!

RCP:TERM (727, 1003), LINE (1, 0), TIDREQ, YES!

where the No and Yes entries are read from Item 12.

Earlier, a recent change message was entered to define that the CSCs in RSL 001 have optioned to pay for all messages from restricted terminals in that group.

RCP:RSL 001, CSC!

This message is entered when the CSCs belonging to RSL 001 are initially defined.

4.7 Common Language Circuit Identification

Each circuit required in the establishment of the Transaction Network Service is identified using a CLCI for special services. This code will appear on circuit and service orders and all related records and should be included in the remarks column of the office records forms.

Example of CLCI: Each circuit from the message switch to a primary DSS or between DSSs bas the following format:

CIRCUIT 1 TMDT XXXXXX.001

CIRCUIT 2 TMDT XXXXXX.002

where XXXXXX is a serial number assigned by the OTC. The circuit between a DSS and a polled terminal has the format

$$\text{TND} \genfrac{}{}{0pt}{}{\text{T}}{\text{C}} \text{TNE NXX XXXX}$$

where T is used for OTC-provided terminals, C is used for customer-provided terminals, TNE is the exchange of the polled terminals, and NXX XXXX is the seven-digit directory number of the polled terminal.

Example: In this example, the CLCI for the circuits to the DSS are assigned:

CIRCUIT 1 TMDT 123456.001

CIRCUIT 2 TMDT 123456.002

as shown on Fig. 4.

The circuit between the DSS and the terminal being assigned is:

TNDT 200 727 1003

4.8 Traffic measurements

The objectives of the traffic measurement plan are to provide data that will allow engineering of the traffic sensitive elements of the service, provide grade of service indications to allow for assignments and rearrangements, and provide information for traffic forecasting.

Although Transaction Network Service differs technically from regular telephone service, the basic call processing is similar. This has allowed the measurements and procedures to be kept in terms used in currently administering telephone switching systems.

Measurements are reported on quarterly (Q), hourly (H), and daily (D) schedules. All measurements on a particular schedule can be reported on the hour, half hour, or quarter hour by setting the Traffic Work Table from the administrative teletypewriter. The reporting interval may range over any period, continuous or disjoint, of the day.

Measurements are divided into calling type or function—polled, dial-in, CSC, buffer, and miscellaneous. Within each category, the measurements are of two types, office total or unit measurement. Office total refers to the total of the defined events occurring at the message switch. The office total measurements are structured similarly for the polled, dial, and CSC categories and are specifically applicable to the

determination of real-time capacity. Unit measurements are line or group measurements within a calling type and are applicable to the engineering of polled access circuits, line hunting groups, and CSC lines, and are available on a special-study basis.

Example of Traffic Measurements—Polled Access Network Measurements: The office totals include counts of all calls originated by the polled terminals served by the message switch. The calls are further broken down into categories of ineffective attempts, and completed calls are calculated as the difference between originating calls and ineffective (service messages are not counted as completed calls). The ineffectives are totaled and also calculated as a percentage of originating calls. Retransmitted response messages, service messages, and DSS test messages are counted separately.

The unit measurements on each half of a polled access circuit are used in engineering and assignment purposes. They include peg counts of originating and terminating calls, line usage, and maintenance usage. In addition, originating and terminating calls for individual terminals on both halves of a polled access circuit are available on demand for use when reconfiguration of terminals on a polled access circuit is under study.

Example: The network administrator would request unit measurements on both halves of the polled access circuit in question and, using the traffic curve shown in Fig. 3, would determine which half to add the polled terminal to.

V. SUMMARY

This paper has described the maintenance and administrative goals and practices developed for the Transaction Network Service. The principal considerations have been to provide reliable, available, and maintainable service to customers while fitting this new service to the existing operating telephone company environment.

VI. ACKNOWLEDGMENTS

The ideas presented in this paper are the results of cooperation among numerous people of the Transaction Systems Department, the Transaction Network Communications Department, and the Auxiliary Processor Systems Department of Bell Laboratories.

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